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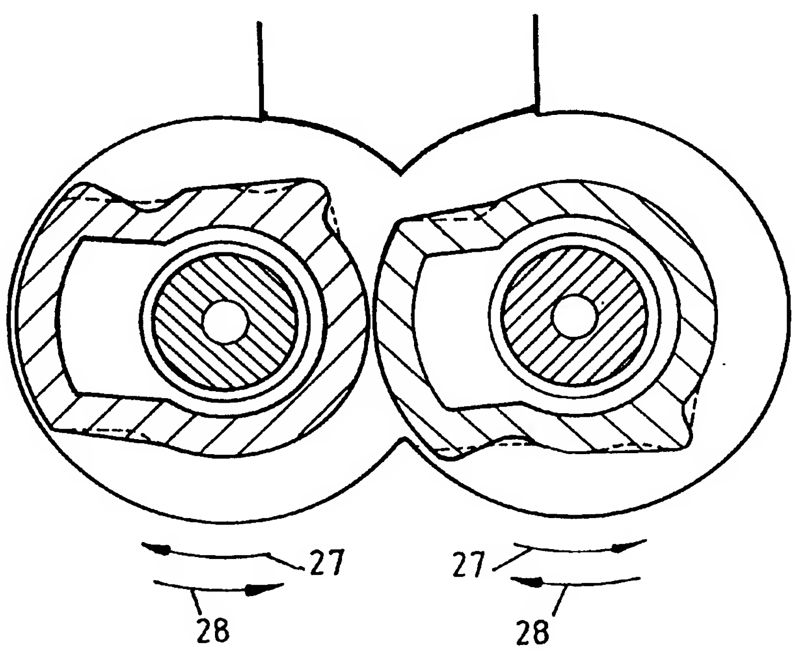

(57) Abstract

An internal mixer comprising at least one rotor supported to rotate about a predetermined axis within a mixing chamber, at least one projection mounted on the or each rotor and extending towards an internal wall of the chamber, and means for rotating the or each rotor about its axis, the said at least one rotor defining projection edges of different geometries and being rotated such that each of the said edges is a leading edge in at least part of a mixing cycle, whereby material within the chamber is subjected to different mixing actions by the edges of different geometries.

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INTERNAL MIXERS

The present invention relates to internal mixers which are used for mixing batches of compound incorporating different components which must be mixed together to provide a homogenised mixture.

Various designs of internal mixers are currently in use in for example the rubber and plastics industries to produce compounds for a wide range of products, for example tyres, electrical insulation plastics and the like. In such mixers, components such as rubber, fillers, reinforcing agents, chemical additives and curatives are introduced into a mixing chamber through an inlet passageway leading to an opening in a wall of the chamber. At least one rotor turns within the chamber, the rotor supporting projections which extend towards the internal wall of the chamber.

The rotor has to perform a number of functions. Firstly bulk materials, for example large pieces of rubber, must be drawn into the chamber and divided into smaller pieces or at least re-shaped. Secondly, the temperature of the material within the chamber must be increased by the application of stresses and strains. The temperature increase is primarily a result of the stress applied to the material through contact with the internal surfaces of the mixer, that is the surfaces of the chamber walls and of the or each rotor. The major criteria in applying stress are

firstly that the material is in contact with machine surfaces and secondly that there is relative movement between the material and the surfaces. Thirdly, the separate components of the mixture must be distributed throughout the volume of the chamber in order to achieve a fine distribution of the various ingredients. For example, filler agglomerates must be dispersed and broken down into a desired fine particle size and then distributed through the bulk of the compound in the mixer. Fourthly, the mixed compound must be plasticized in order to achieve the requisite final rheological properties. Finally, all of the fully mixed compound must be discharged from the mixer through an outlet which can be opened in the chamber wall.

Given the different functions which the mixer must perform during a single batch mixing operation, and given the changes in the properties of the mixed material during the course of a batch mixing operation, the design of internal mixers must be such that adequate performance is achieved in all the phases of a mixing operation. As a result it is always necessary to compromise on certain features of the design of an internal mixer to ensure that the overall performance is acceptable. By way of example, internal mixers with interlocking rotors are widely used in the rubber industry. In such mixers, two rotors are arranged side by side within a single chamber with their axes of rotation parallel. The rotors comprise projections or nogs supported on generally

cylindrical shafts, the radially outer end of the nogs on one rotor extending to a short distance from the adjacent inner wall of the cavity and a short distance from the surface of the shaft of the other rotor. The rotation of the two rotors is synchronised to ensure that the nogs on one rotor do not contact the nogs on the other. With an interlocking rotor mixer of this type, a single batch mixing operation involves three separate phases. Firstly, the rotors serve to ingest the materials into the cavity, to distribute them around the chamber, and initially to plasticate the materials by means of the stressing action taking place between the rotors. Secondly, as the material is heated and softens, it begins to flow over the radially outer edges of the nogs, that is through the gap between the nogs and the chamber walls. Because of the length and width of this gap, the material is subjected to substantial extensional and shear stresses and strains, thereby achieving good dispersion, while the disposition of the nogs on the rotors provides a degree of circulatory flow within the chamber, thereby assisting with the distributive mixing. Thirdly, the rotors serve to propel the compound downwards and outwards through the outlet when a discharge door is opened at the end of the mixing cycle.

The configuration of the nogs on the rotors of an internal mixer with interlocking rotors has been evolved over many years. A design which is currently in general use is described in European Patent Specification 0 170 397. In that design the rotors are separated by a gap

which is large enough to ensure that sufficient space is available to ingest the material relatively easily, but which is small enough to ensure that adequate extensional and shear stresses and strain rate can be applied to the material in order to obtain dispersive mixing of its components. The larger the rotor gap, the greater the ingestion but the less the dispersion. Accordingly the selection of the rotor gap must be a compromise given the competing requirements. It is also necessary to tailor the method of operation of the machine to the particular stage of the mixing cycle, for example to reflect the physical and chemical condition of the material. This can involve the variables of speed of rotation, the pressure with which material to be ingested is forced into the chamber opening, the temperature of the mixture and the time for which the mixture is worked. Of these variables, temperature control is generally the most significant. It is therefore necessary to design internal mixers in such a way as to ensure that the required levels of extensional and shear stresses, strains, and temperature are achieved at all stages of the cycle whilst seeking minimum cycle times. Given the changing rheological properties of the mixture during the cycle, these factors cannot be readily optimised during all parts of the cycle. Thus the design of the know internal mixers represents a set of carefully established compromises.

Known internal mixers are conventionally driven in a single direction during the normal mixing process. In mixers with two contra-

rotating rotors, the leading edges of the two rotors are geometrically substantially identical. Thus each rotor subjects the material to be mixed to the same mixing action. It is believed that in some circumstances it has been possible to reverse the direction of rotor movement to facilitate the release of jammed rotors but it is not believed that internal mixers have ever been operated in a normal mixing cycle which includes phases during the process of mixing a single batch during which the direction of rotation of the rotors is reversed.

It is an object of the present invention to provide an improved internal mixer.

According to the present invention, there is provided an internal mixer comprising at least one rotor supported to rotate about a predetermined axis within a mixing chamber, at least one projection mounted on the or each rotor and extending towards an internal wall of the chamber, and means for rotating the or each rotor about its axis, the said at least one rotor defining projection edges of different geometries and being rotated such that each of the said edges us a leading edge is at least part of a mixing cycle, whereby material within the chamber is subjected to different mixing actions by the edges of different geometries.

In one embodiment of the present invention, the rotating means rotates the or each rotor in either direction about its axis, and the or each projection is formed such that the shapes of its leading and trailing edges

are different, whereby the mixing action to which material within the chamber is subjected is a function of the direction of rotation of the rotor.

The invention also provides a method for operating an internal mixer comprising at least one rotor supported to rotate about a predetermined axis within a chamber, and at least one projection mounted on the rotor and extending towards an internal wall of the chamber, the or each projection, being formed such that the shapes of its leading and trailing edges are different, wherein a batch of material is delivered to the cavity, the or each rotor is rotated in a first direction to subject the material to a first mixing programme in which the mixing action is appropriate to its initial condition, and the direction of rotation of the or each rotor is reversed at least once to subject the material to at least one further mixing programme in which the mixing action is appropriate to the condition of the material after completion of the first mixing programme.

In an alternative embodiment of the present invention, in which at least one rotor is provided defining at least two projections, the or each rotor is rotated in only one direction during a mixing cycle, the leading edge of at least one projection is relatively steep so as to grip material to be ingested and force it into the chamber, and the leading edge of at least one other projection is relatively less steep so as to encourage material to flow over the radially outer surface of the projection.

The present invention is based upon the realisation that in an internal mixer it is the leading edge of the projection which largely determines the mixing action to which material within the chamber is subjected. Thus by arranging for the rotor to be reversible and reversing the direction of rotation of the rotor during the mixing of a single batch, improved performance can be achieved by designing the leading edge of the projections when the rotor turns in one direction to be appropriate for the condition of materials at one stage of the mixing cycle, and designing the leading edge of the projections when the rotor turns in the opposite direction to be appropriate for the condition of the material to be mixed at another stage of the mixing cycle. Alternatively, in a double rotor machine in which the rotors turn in only one direction during a complete mixing cycle, one rotor can have a leading edge which ensures rapid ingestion of material at the beginning of a mixing cycle and the other rotor a leading edge appropriate to a later stage in the same mixing cycle.

In a machine with reversible rotor direction, the rotor direction may be reversed two or more times during a single batch cycle, for example to assist in material discharge, or to ensure good dispersion/distribution of ingredients added to the compound during the course of the mixing cycle. Thus the designer can produce an internal mixer with characteristics that in the prior art would have required two separate mixers used sequentially to process a single batch.

A first edge of the or each projection which is the leading edge when the rotor is rotated in one direction may be relatively steep so as to grip material to be ingested and thereby force material into the chamber, whereas a second edge of the or each projection which is the leading edge when the rotor is rotating in the other direction is relatively less steep so as to encourage material to flow over the radially outer surface of the projection, thereby providing for optimal extension flow into the gap and shear flow within the gap. The first edge is the leading edge during initial material ingestion and plastication, and the second edge is the leading edge during a subsequent stage in the mixing cycle. It would of course be possible in a further stage of the mixing cycle to again reverse the direction of rotation of the rotor.

The first leading edge may be inclined at an angle of less than 45^{o} to a radius drawn from the axis of rotation. The smaller this angle, the steeper the surface of the projection advancing towards the material to be mixed. That steep edge may be provided with an undercut so as to positively grip introduced material and in addition could have sharp corners so as to assist in breaking up initially introduced materials.

The or each projection may be provided with indentations and depressions that are sloped in the helical, axial or circumferential direction so as to improve material distribution. It will be appreciated that in contrast to prior art mixers which during a mixing cycle rotated in

only one direction it would be possible in accordance with the present invention to provide projections defining spaces which are "dead", that is to say which are not swept out by the flow of material within the mixer when the rotor turns in one direction, providing those areas are swept out when the direction of rotation is reversed.

The present invention is applicable to a variety of internal mixer designs but is particularly applicable to mixers having two rotors located with the nip between them beneath a material inlet and above a material outlet, the rotor supporting interlocking projections shaped such that the leading edges of the projections when the rotors are rotated to move the projections downwards at the nip grip material introduced through the inlet, and such that the leading edges of the projections when the rotors are rotated to move the projections upwards at the nip force material within the chamber against the internal wall of the chamber.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which;

Figure 1 is a view from above of two rotors of a conventional internal mixer in which such rotors are arranged side by side within a mixing chamber;

Figure 2 is a sectional view on the line-to-to of Figure 1;

Figure 3 is a sectional view corresponding to that of Figure 2 showing the ingestion of material to be mixed;

Figure 4 illustrates a later stage in the mixing process shown in Figure 3;

Figure 5 illustrates the structure of an alternative internal mixer of conventional form;

Figure 6 is a view similar to that of Figure 2 but showing modifications made to the cross-section of a rotor in accordance with the present invention; and

Figure 7 illustrates in cross-section the rotors of a reversible mixer in which each rotor has been modified in the same manner as the rotor of Figure 6;

Figures 8 and 9 schematically represent modifications which may be made to a rotor in accordance with the present invention; and

Figure 10 illustrates in cross-section the rotors of a mixer in which each rotor rotates in only one direction but the rotors have been modified in different ways such that the rotors subject material within the mixer to different mixing actions.

Referring to Figures 1 and 2, the illustrated conventional internal mixer is manufactured by the applicants and is sold as the "Intermix" internal mixer. The illustrated mixer comprises a casing defining an internal wall 1 within which rotors 2 and 3 are supported. The rotor 2 is supported on a shaft 4 and in use is rotated in the direction of arrow 5. The rotor 3 is supported on shaft 4 and in use is rotated in the direction of

arrow 6. The rotor 2 has a cylindrical outer surface from which projections 7, 8 and 9 extend towards the wall 1. The rotor 3 supports projections 10, 11 and 12 which also extend towards the wall 1. The projections 7 and 10 define portions of a helix and the rotors are arranged such that the projection 7 is received in the spacing between projections 11 and 12 as the two rotors are turned and the projection 10 is received between the two projections 8 and 9 as the rotors turn. Thus the projections of the two rotors are interlocked and such mixers are generally referred to as having interlocking rotors. At the nip defined between the two rotors there is a small clearance between the radially outer surface of the projections on one rotor and the adjacent cylindrical surface of the other rotor.

The projection 10 defines a leading edge 13 which subtends an angle 14 of about 53° with a radius drawn from the axis of rotation of the rotor. That same projection defines a trailing edge 15 which defines an angle 16 relative to a radius. The angles 14 and 16 are substantially the same. Similarly, the projection 11 defines a leading edge 17 defining an angle 18 of about 47°, and a trailing edge 19 defining an angle 20 which is substantially the same as the angle 18. Thus the shape of the leading edge of each projection is substantially the same as the shape of the trailing edge of each projection. The shape is not always identical and in some forms of the Intermix internal mixer manufactured by the applicants

there are minor differences between the shapes of the leading and trailing edges as can be appreciated from the disclosure of European Patent Specification 0 170 397. These differences between the shape of the leading and trailing edges are relatively minor however and are generally concerned with smoothing the flow of material over the projections in regions adjacent the axial ends of the rotors.

The casing incorporates an inlet 21 in which a ram 22 is slidably received. The casing also comprises an outlet beneath the nip between the rotors. The outlet is now shown in Figures 1 and 2 but it will be appreciated that it comprises a door which is normally fixed in position and which can be opened to discharge a batch of mixed material from the chamber.

Figure 3 illustrates the operation of the mixture of Figures 1 and 2 when a batch of raw polymer is ingested. The polymer is generally supplied in relatively large pieces and must be broken down within the mixer. The introduced material may be pressed down by the ram into the nip of the rotors and the material is gradually drawn into the mixing chamber through the narrow gap between the rotors. The gap between the rotors and the degree to which the material to be ingested is gripped by the rotors significantly affect the rate at which material can be ingested.

Referring to Figure 4, this illustrates the disposition of the material being mixed shortly before the end of the processing of a batch of material. It will be seen that ram has been lowered considerably as compared with Fig. 3 and material now passes over the radially outer surfaces of the projections. The material is also worked between the rotors. The rheological conditions within the chamber are clearly very different at the beginning of a batch processing as illustrated in Figure 3 and at the end of the same batch as illustrated in Figure 4. At the beginning of the process, it would be advantageous to widen the gap between the rotors so as to speed up ingestion and increase the usable volume of the mixer. The gap cannot be too large however if the components of the material to be mixed are to be adequately stressed and distributed. At the end of the process, when the material to be mixed is warm and relatively soft, it is desirable for the material to be forced between the radially outer surfaces of the projections and the chamber wall so as to ensure adequate extensional shear stresses and strain rates to obtain dispersive mixing of the components. The pressure upstream of the projections is partly a function of the steepness of the leading edge of the projections. As the material softens, it is desirable that the proportion of the material which is circulated between the helical projections rather than forced over the radially outer surface of those projections tends to decrease, and hence in later stages of the mixing process it would be

desirable to make the leading edges of the projections less steep so as to encourage more material to pass over the radially outer edges of the projections thereby generating significant extensional stressing and shear stressing of the material. The varying rheological properties of the material to be mixed hence forces the mixer designer to adopt a whole series of compromises when it comes to the configuration of the rotors. The leading edges of the projections are not as steep as would be ideal for the initial phases of a mixing process for ingestion and distribution but are steeper than would be desirable for the final stages of that process for dispersion.

The problems of detailed rotor designs associated with interlocking rotor mixers of the type illustrated in Figures 1 to 4 are encountered in other mixers, for example the Banbury-type mixer schematically illustrated in Figure 5. In that mixer a rotor 23 turns about axis 24 within a chamber 25. Material 26 to be mixed is trapped between the chamber wall and the rotor and as a result the material is smeared against the chamber wall. Given that the rheological properties of the material to be mixed vary over time due to heating and plasticisation the profile of the rotor is once again a compromise, the angle between the rotor surface adjacent the chamber wall and the wall itself being sufficiently large to ensure that a fresh batch of material can be ingested but sufficiently small to ensure that the softened material is adequately stressed. Once again, in

internal mixers of the type schematically illustrated in Figure 5 the rotor is turned in one direction only and there is no significant difference between the configuration of the rotor surface as between the upstream and downstream sides of that surface.

It has been known to provide an internal mixer of the type illustrated in Figures 1 to 4 with a reversible motor to enable the rotors to be driven in reverse to assist in releasing a jammed mixer. No proposals have been made however to drive the rotors of an internal mixer in both directions during a normal mixing process cycle.

The present invention relies upon a realisation that a rotor can be designed to provide a first set of conditions within a mixing chamber when rotated in one direction and a second set of conditions when driven in the opposite direction. By shaping the circumferentially spaced sides of the projections in an appropriate manner, a rotor can be designed which provides a performance equivalent to that which would be achieved by using separate first and second mixers sequentially, the first mixer in the sequence being designed to optimise performance in a first phase of a batch mixing process and the second mixer being designed to optimise performance for the completion of that process. All that is required to put the invention into practice is a redesign of the circumferentially spaced surfaces of the projections and the provision of a drive mechanism

which is capable of driving the rotors in both directions over significant periods of a mixing cycle.

Figure 6 illustrates a rotor modified in accordance with the present invention, and Figure 7 illustrates in cross-section the two rotors of the machine in which each rotor has the same configuration as that of Figure 6. The general structure of the rotor of Figure 6 is identical to that of the rotor to the left hand side of Figures 2 to 4 but it will be seen that the upstream edges of the projections when the rotor turns in the direction of arrow 27 have been made more steep whereas the upstream edges of the projections when the rotor is rotating in the direction of arrow 28 have been made less steep. The shape of the surfaces before modification in accordance with the present invention is indicated in Figure 6 by the dotted lines 29. Given the modification of the rotor as shown in Figure 6 and equivalent modifications to the right hand rotor as shown in Figures 2 to 4, to produce the arrangement shown in Figure 7, and assuming reversal of the direction of rotation of the rotors at appropriate times, various benefits arise. Firstly, by increasing the steepness of the leading edges of the projections when turning in the direction of arrow 27 the material within the mixer can be more positively gripped by the rotors to improve ingestion, transport of material within the chamber, and discharge of material from the chamber. In particular, the speed of ingestion is increased and the gap between the rotors may be increased to

further improve the speed of ingestion and discharge and to increase the usable volume of the mixer. Secondly, by decreasing the steepness of the leading edges of the projections when turning in the direction of arrow 28 greater quantities of material are subjected to high stress and strain.

Figure 8 illustrates one simple modification to a projection which can be made in accordance with the present invention. To simplify the illustration, Figure 8 shows the projections having straightened out the curvature due to the cylindrical outer surface of the main rotor body. The full line in Figure 8 represents the configuration of the projection of a conventional mixing machine of the type shown in Figures 2 to 4, whereas the dotted line shows the configuration of a modified projection in accordance with the present invention. The arrow 30 represents the direction of movement of the projection during the initial phases of the mixing process in which the relatively steep leading edge enables the introduced material to be positively gripped and forced into the chamber interior. The arrow 31 represents the direction of movement of the projection after reversal of the mixer drive such that the relatively gently sloping leading edge of the projection encourages material to travel up that leading edge and over the upper portion of the projection during which time it is subjected to high stress.

Figure 9 illustrates yet another conceivable configuration for a modified projection for use in an embodiment of the present invention.

Again the dotted line represents the configuration of the modified projection, whereas the full line shows the standard configuration. It will be seen that the leading edge (in the direction of arrow 30) is undercut so as to provide a very secure "gripping" of material during the ingestion phase. Again the leading edge (in the direction of arrow 31) is a relatively gentle slope so as to provide extensional flow within the conveying and diverging gaps and to encourage material to flow onto the radially outer surface of the projection. It may be that the undercut configuration as shown in Figure 9 would result in "dead" or stagnant space which would not be adequately swept out if the rotor always turned in the direction of arrow 31. This need not be a problem however providing during the final stages of a mixing cycle the rotor turns in a direction which avoids any dead spaces occurring. For example, during the initial ingestion phase the projection could move in the direction of arrow 30, the rotor direction could then be reversed until immediately before the completion of the mixing cycle, and the discharge portion of the cycle could be effected after a further reversal of the direction of rotation of the rotors such that during the discharge phase the projection moves in the direction of arrow 30.

It will be appreciated that in addition to the control of the direction of rotation of the rotors, a mixing cycle can also be controlled by adjusting the speed of rotation, the ram pressure, coolant temperature

and mixing cycle duration. The embodiment of the present invention described in Figures 6 to 9, in proposing the reversal of the direction of rotation of the rotors in association with a modification to the shape of the rotor projections, adds a further variable which can be used to control the mixing cycle. The rotors can be designed to optimise ingestion, distribution and discharge operations while the rotors operate in one direction (downwards at the nip) and to optimise dispersion and plastication while the rotors turn in the opposite direction (upwards at the nip).

The relatively steep edges of the projections may be given surface features to improve the gripping of material during the ingestion phase. As illustrated in Figure 9 undercuts may be formed but alternatives are possible, for example the provision of relatively sharp corners on the projection edges. In addition, the surfaces of the projections and of the rotor between the projections may be provided with indentations and depressions that are sloped in the helical, axial or circumferential directions. Experimentation will be necessary to define the optimum configuration.

In a double rotor mixer with contra-rotating rotors, during the ingestion phase high pressure develops above the nip between the rotors and beneath the ram. When the rotors are reversed, high pressure develops beneath the nip in the region of the chamber discharge door.

The discharge door is fixed in position and thus serves as a high pressure ram to ensure that the material to be mixed is subjected to high stress.

The concept of rotor direction reversal with modification of the projection surfaces provides an extra control variable which can be used for example to achieve shorter cycle times and/or greater mixing capacity as a result of the closer match between the machine configuration and specific processing needs.

An alternative embodiment of the invention is illustrated in Figure 10. This embodiment comprises contra-rotating rotors 32 and 33 but the rotors turn in only one direction as indicated by arrows 34. The leading edges 35 and 36 of the projection on rotor 32 have been made relatively more steep by changing their shape from that indicated by dotted lines. The trailing edges 37 and 38 are of conventional shape, corresponding to the shapes shown in Figures 3 and 4, in contrast, the leading edges 39, 40 of the projections on rotor 33 have been made relatively less steep by changing their shape from that indicated by dotted lines. The trailing edges 41 and 42 are of conventional shape.

In the embodiment of Figure 10, the relatively steep leading edges 35, 36 of the projections on rotor 32 ensure rapid ingestion of material into the mixer. The leading edges 39, 40 of the projections on rotor 33 then ensure that the material is subjected to high stress and strain.

CLAIMS

1. An internal mixer comprising at least one rotor supported to rotate about a predetermined axis within a mixing chamber, at least one projection mounted on the or each rotor and extending towards an internal wall of the chamber, and means for rotating the or each rotor about its axis, the said at least one rotor defining projection edges of different geometries and being rotated such that each of the said edges is a leading edge in at least part of a mixing cycle, whereby material within the chamber is subjected to different mixing actions by the edges of different geometries.

2. An internal mixer according to claim 1, wherein the or each projection is formed such that the shapes of its leading and trailing edges are different, and the rotating means rotates the or each rotor in either direction about its axis, whereby the mixing action is a function of the directions of rotation of the or each rotor.

3. An internal mixer according to claim 2, wherein the or a first edge of the or each projection which is the leading edge when the rotor is rotated in one direction is relatively steep so as to grip material to be ingested and thereby force material into the chamber, and wherein a

second edge of the or each projection which is the leading edge when the rotor is rotated in the other direction is relatively less steep so as to encourage material to flow over the radially outer surface of the projection.

4. An internal mixer according to claim 3, wherein the first leading edge is inclined at an angle of less than 45° to a radius drawn from the axis of rotation.

5. An internal mixer according to claim 3 or 4, wherein the first leading edge is undercut.

6. An internal mixer according to claim 3, 4 or 5, wherein the first leading edge defines at least one sharp corner.

7. An internal mixer according to any one of claims 2 to 6, comprising two rotors located with the nip between the rotors beneath a material inlet and above a material outlet, the rotor supporting interlocking projections shaped such that the leading edges of the projections when the rotors are rotated to move the projections downwards at the nip grip material introduced through the inlet, and such that the leading edges of the projections when the rotors are rotated

to move the projections upwards at the nip force material within the chamber between the internal wall of the chamber and the radially outer surface of the projection and/or between the rotors.

8. An internal mixer according to claim 1, comprising at least one rotor defining at least two projections, the or each rotor being rotated in only one direction during each mixing cycle, wherein the leading edge of at least one projection is relatively steep so as to grip material to be ingested and thereby force material into the chamber and the leading edge of at least one other projection is relatively less steep so as to encourage material to flow over the radially outer surface of the projection.

9. A method for operating an internal mixer in accordance with any one of claims 2 to 7, wherein a batch of material is subjected to a first mixing action by rotating the rotor in a first direction to ingest and plasticate the material, and the plasticated material is then subjected to at least one further mixing action by reversing the direction of rotation at least once.

10. An internal mixer substantially as hereinbefore described with reference to Figures 6, 7, 8, 9 or 10 of the accompanying drawings.

11. A method for operating an internal mixer substantially as hereinbefore described with reference to Figures 6, 7, 8, 9 or 10 of the accompanying drawings.

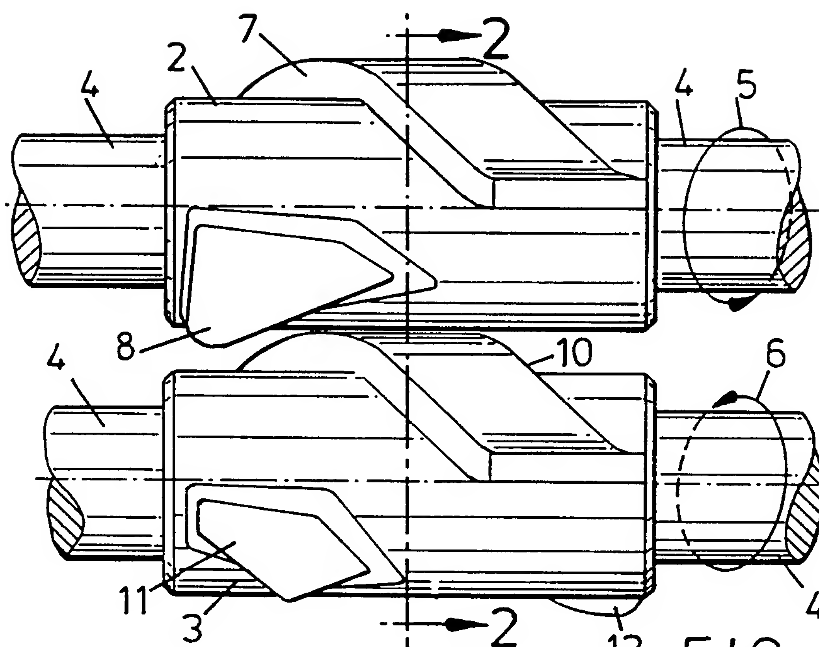
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FIG.1

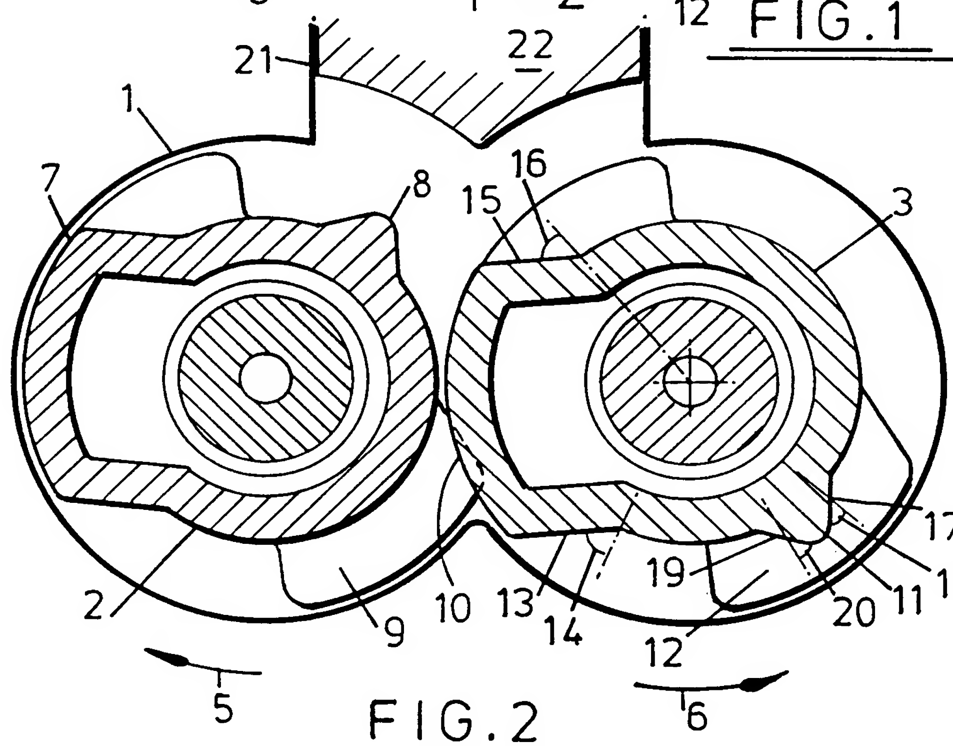
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FIG.2

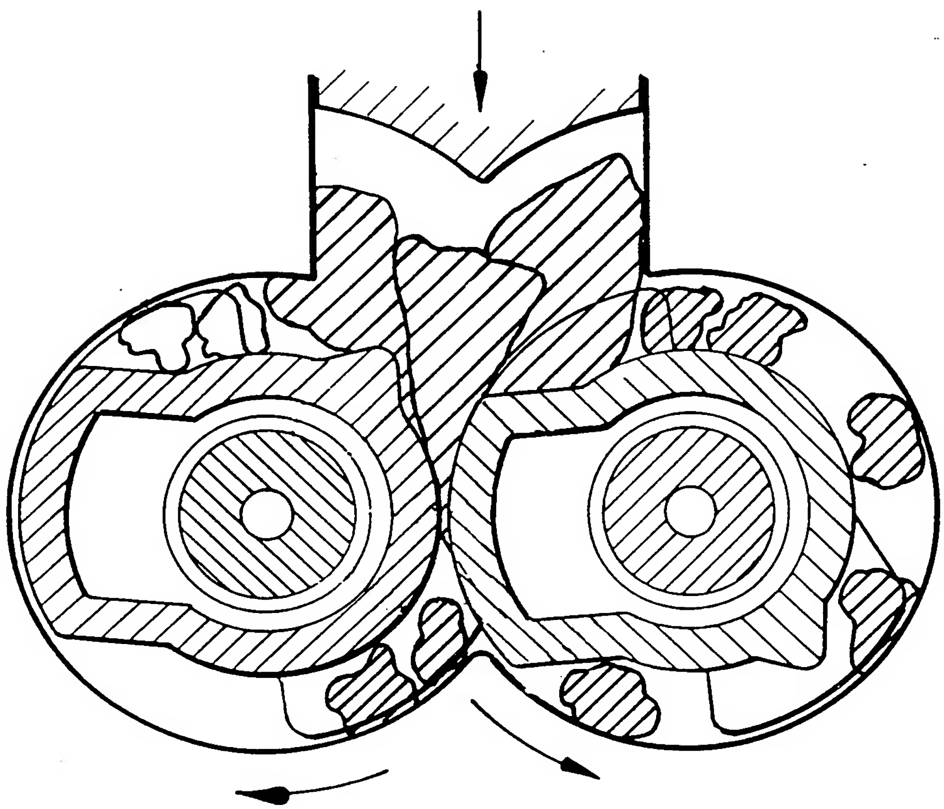

FIG. 3

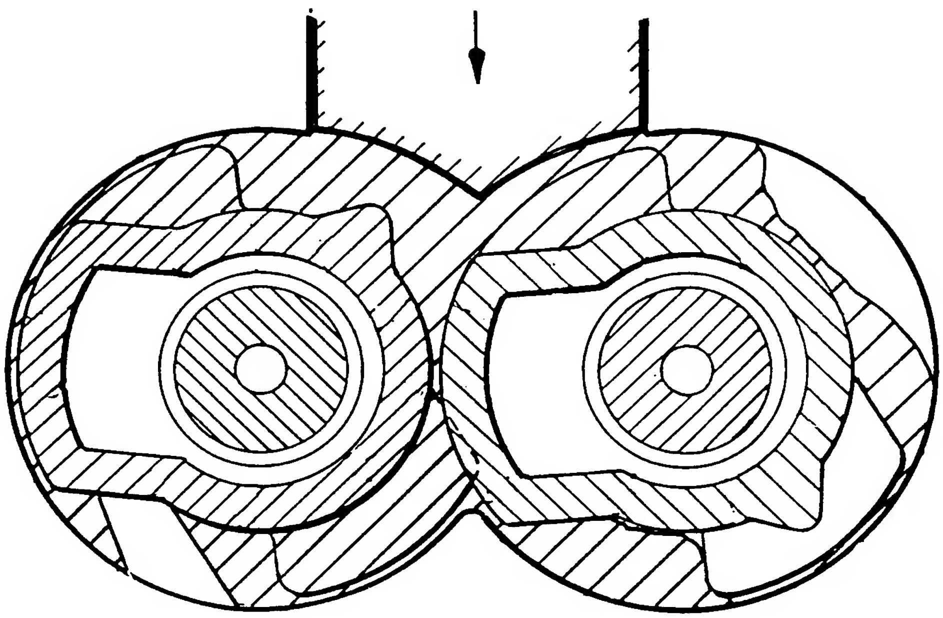

FIG. 4

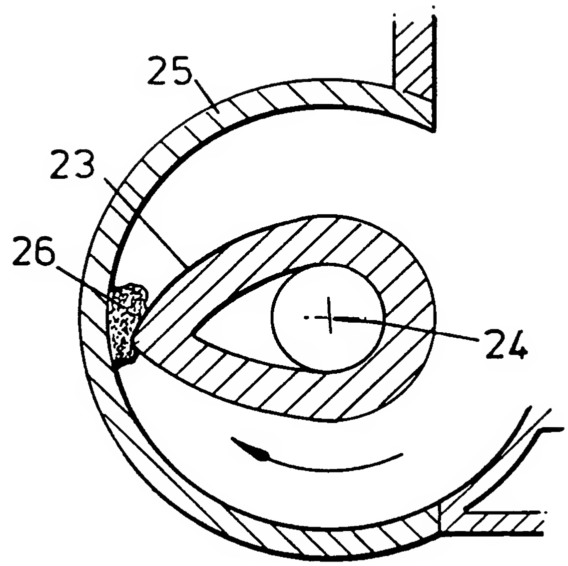

FIG.5

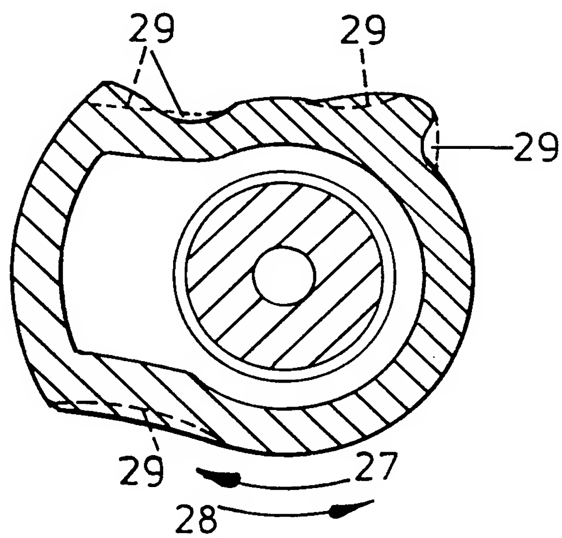

FIG.6

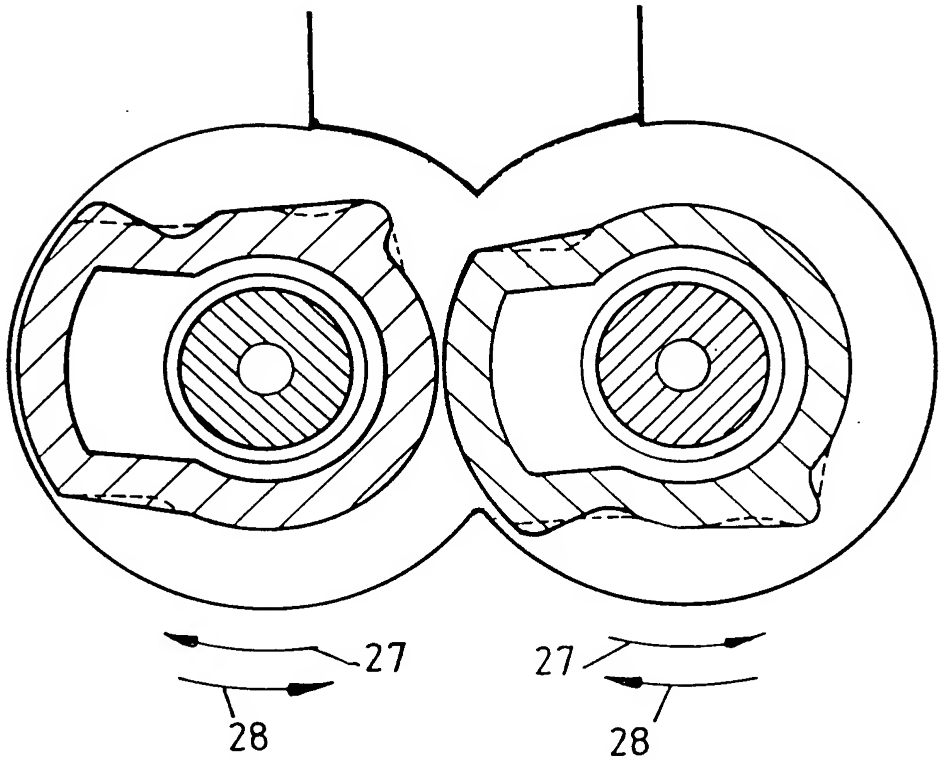

FIG.7

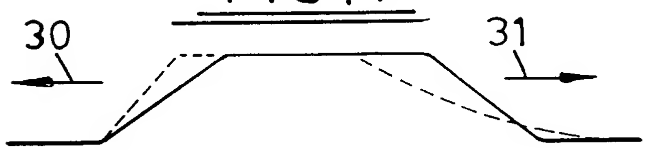

FIG.8

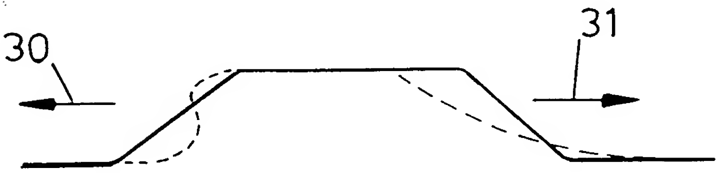

FIG.9

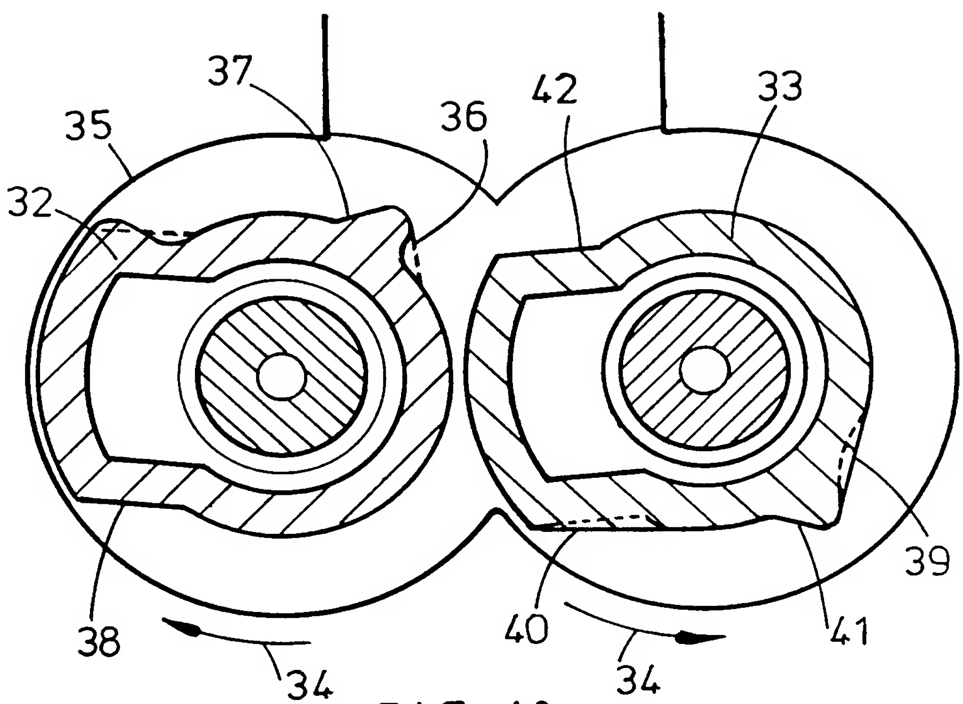

FIG.10

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 96/01128

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B01F7/02 B29B7/18 B29B7/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B01F B29B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 340 888 (FARREL CORP) 8 November 1989	8
A	see figures 2,7-7E	1-7,9
A	US,A,4 053 144 (ELLWOOD HENRY) 11 October 1977 see figure 3	1-9
A	US,A,4 917 501 (SIMONET DOMINIQUE ET AL) 17 April 1990 see figure 2	1-9
A	EP,A,0 483 727 (SUMITOMO HEAVY INDUSTRIES) 6 May 1992 see figures 1A-1D	1-9

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

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Date of the actual completion of the international search	Date of mailing of the international search report
8 August 1996	03.09.96
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Authorized officer Kanoldt, W

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 96/01128

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 170 397 (SHAW PLC FRANCIS) 5 February 1986 cited in the application ---	
A	US,A,4 300 838 (SATO NORIMOTO ET AL) 17 November 1981 ---	
A	GB,A,2 002 247 (FARREL BRIDGE LTD) 21 February 1979 -----	

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 96/01128

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-0340888	08-11-89	US-A-	4834543	30-05-89
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		AU-B-	3028289	19-10-89
		CA-A-	1299562	28-04-92
		JP-A-	1307436	12-12-89
		JP-B-	8024833	13-03-96
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 96/01128

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A-4300838		JP-A-	55003838	11-01-80
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		AU-B-	4834779	03-01-80
		DE-A-	2925250	03-01-80
		FR-A,B	2429088	18-01-80
		GB-A,B	2027600	27-02-80
GB-A-2002247	21-02-79	CA-A-	1115690	05-01-82
		US-A-	4184773	22-01-80

Form PCT/ISA/210 (patent family annex) (July 1992)

PUB-NO: WO009635507A1
DOCUMENT-IDENTIFIER: WO 9635507 A1
TITLE: INTERNAL MIXERS
PUBN-DATE: November 14, 1996

INVENTOR-INFORMATION:

NAME	COUNTRY
BROWN, CHRISTOPHER JOHN	GB

ASSIGNEE-INFORMATION:

NAME	COUNTRY
SHAW FRANCIS & CO LTD	GB
BROWN CHRISTOPHER JOHN	GB

APPL-NO: GB09601128
APPL-DATE: May 13, 1996

PRIORITY-DATA: GB09509742A (May 13, 1995)

INT-CL (IPC): B01F007/02 , B29B007/18 , B29B007/10

EUR-CL (EPC): B29B007/12 , B29B007/18 , B29B007/20

ABSTRACT:

CHG DATE=19990617 STATUS=O>An internal mixer comprising at least one rotor supported to rotate about a predetermined axis within a mixing chamber, at least one projection mounted on the or each rotor and extending towards an internal wall of the chamber,

and means for rotating the or each rotor about its axis, the said at least one rotor defining projection edges of different geometries and being rotated such that each of the said edges is a leading edge in at least part of a mixing cycle, whereby material within the chamber is subjected to different mixing actions by the edges of different geometries.